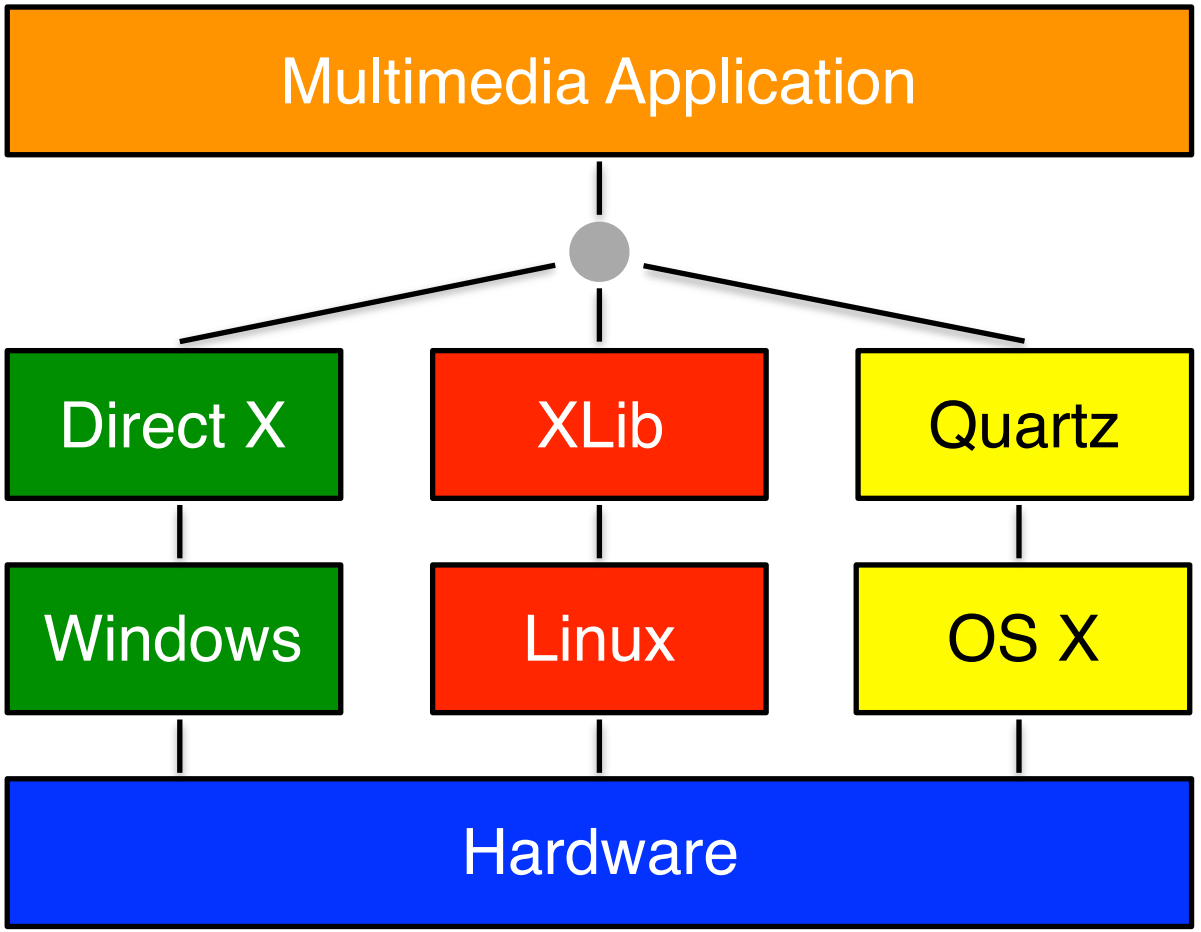
3 Multimedia Programming with C++ and Multimedia Frameworks

Multimedia Support is Platform Dependent

- Example: 2D graphics on desktop/laptop computers

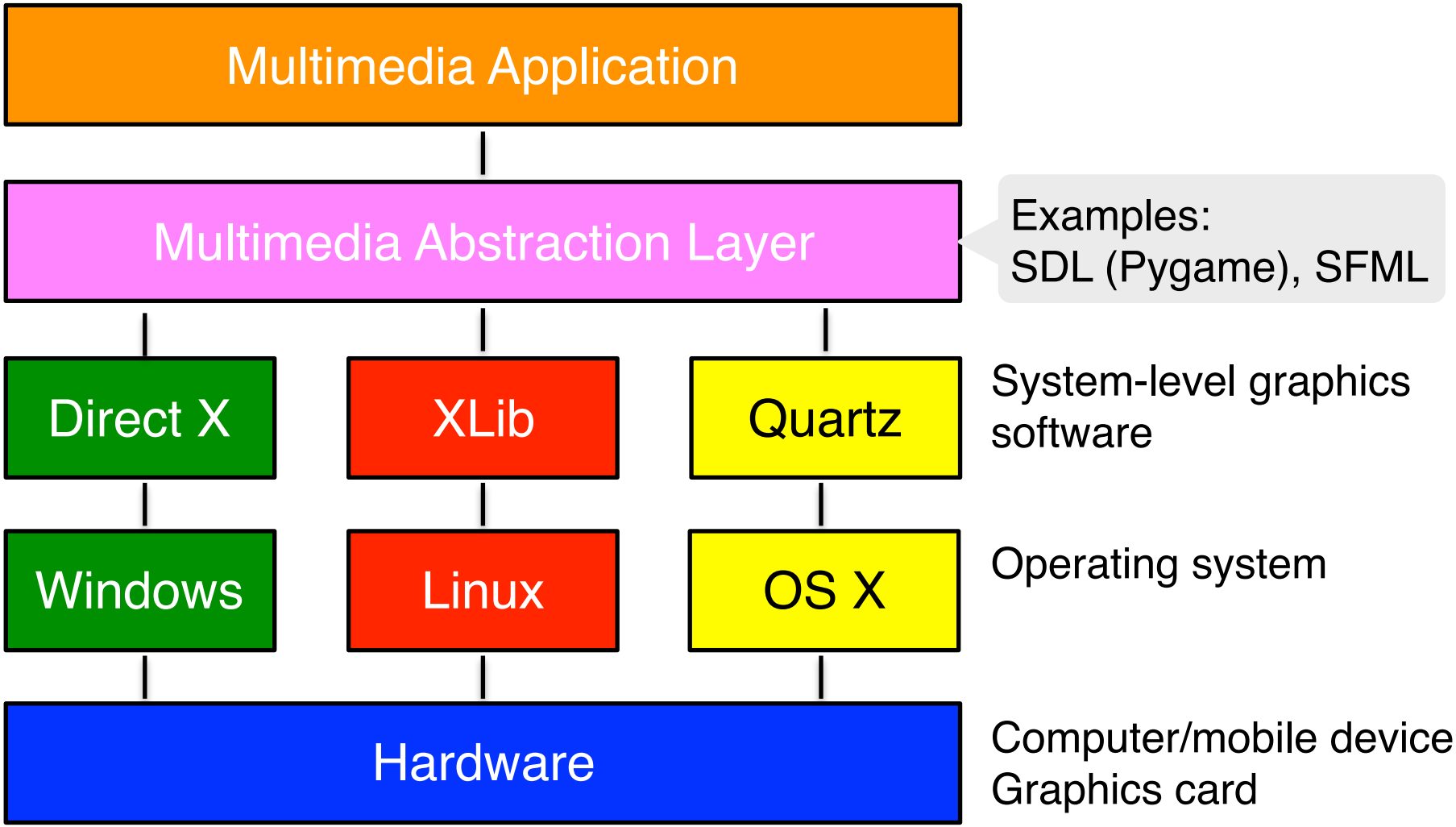


System-level graphics software

Operating system

Computer/mobile device
Graphics card

Multimedia Abstraction Layer



Core Functionality of a Multimedia Abstraction Layer

Graphics
- Surfaces
- Vector Drawing
- Bitmap Images

Sound
- Recording and playing
- Mixing
- Sound files and streams

Moving Images
- Video playback
- Moving 2D images (sprites)
- Translations, transformations

Input/Output and Events
- External devices
- Event queuing

Network
- Sockets
- Protocol support (FTP, HTTP)

Time
- Clock
- Timers

Additional Functionality for Advanced Multimedia Applications (Games)

Object Structure
- Layers, scenes
- Scene graphs
- …

Control Structure
- Activity scheduling
- Time containers
- …

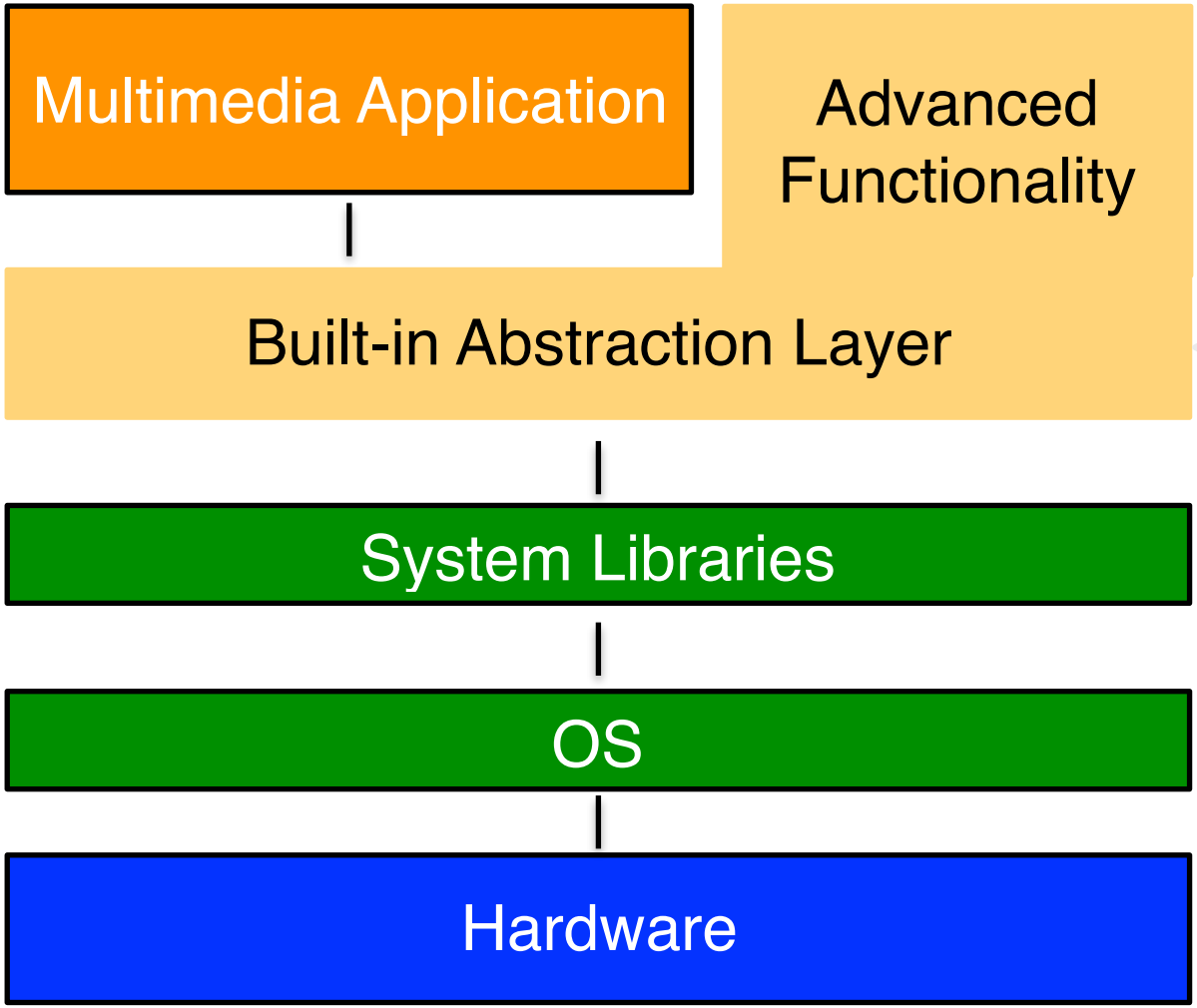
Animation
- Animated images
- Sprite sheet support
- …

Effects
- Interpolators
- Complex transitions
- …

Physics Simulation
- Solid-body physics
- Particle effects
- …

Artificial Intelligence
- Game logic
- Adaptation
- …

High-Level Multimedia Framework



High-level multimedia framework

Examples:
Cocos2d-x, …

Terminology

- Low-Level Multimedia Framework
  = Multimedia Abstraction Layer
  - Platform independent media handling
- High-Level Multimedia Framework
  = Game Engine
  - Advanced multimedia features
  - Specific support for game functionalities
  - In most cases includes low-level multimedia framework

Pseudocode!

Program Control and Frameworks

```
main:
<all preparation work>
while running do:
   <process input>
   <update model>
   <render model>
```

```
def init():
  <specific preparations>
def update():
  <specific updates>

schedule(update)
```

Traditional program control

- We write the main program
- Main control loop is part of our code
- We call functions of the framework

Typical for low-level frameworks

Inversion of program control

- Main program is in the framework
- Main control loop does not appear in our code
- The framework calls our functions
- "Hollywood Principle"

Typical for high-level frameworks

Implementation Language: Criteria

- Handling of multimedia objects
  - Built into the language?
  - Available in standard library? (e.g. Yes for Java 8)
- Portability to target platforms
  - Critical in case of multiple platforms, mobile platforms etc.
- Performance: Memory efficiency
- Performance: Fast execution
- Performance: Access to hardware accelerations
- Performance…

Python, Java, C++

	Python	*Java*	*C++*
Ease of use	easy to learn and use	medium complexity	rather demanding
Multimedia support	not standard available through frameworks (Pygame)	Java 8: well-supported through built-in framework (JFX)	not standard available through frameworks (SDL, SFML, Cocos2d, …)
Multi-platform	basically given limitations regarding multimedia frameworks very limited for mobile devices (being improved by e.g. kivy.org)	basically OK single-source multi-platform limited e.g. for iOS	well supported through frameworks (e.g. Cocos2d-x)
Performance	limited	limited	**very good** (memory, native, hardware acceleration)

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Literature:

http://www.cprogramming.com/java/c-and-c++-for-java-programmers.html

B. Stroustrup: The C++ programming language, 4th ed., Addison-Wesley 2013

C++: History

- C: Dennis Ritchie, Bell Labs, 1969-1973, an improvement of B, which was a simplified version of BCPL
- Bjarne Stroustrup, Bell Labs, 1979: Extension of the C programming language for large-scale programming *(16 years before Java!)*
- ISO standard since 1998 (ISO/IEC 14882)
- Important late revisions and extensions, in particular C++11 (2011)
- C++17 in preparation
- Latest version: C++14 (ISO standard 14882:2014)
- Main features of the language:
  - Object-oriented programming with multiple inheritance
  - Flexible storage allocation models
  - Templates for generic programming
  - Lambda expressions
  - Exception handling
  - Powerful standard library

Differences Java – C Type Languages

- **Good news first:**
  Syntax is very similar!
- Native compilation (C++) vs. compilation to VM (Java)
- Not everything has to be a class in C / C++.
- Preprocessor instead of import

```
#include <string>
```

- Much more flexible (and dangerous) concept of pointers (and references):
  Pointers may refer to any storage area, in particular to memory on the stack!
- Objects can be created in C++ on the stack (static memory), not only on the heap (dynamic memory).
- Allocated memory on the heap (new) does ***not*** have automatic garbage collection. Memory has to be freed explicitly by "delete".

Pointers and References in C++

- Address-of Operator (&)

  ```
  int myvar = 25;
  ```

  `&myvar` is the memory address of `myvar` (on the stack)

- Pointer type declaration:

  ```
  int* ptr = &myvar;
  ```

  Printing `ptr` shows a memory address (e.g. `0x7fff5fbff698`)

- Dereference Operator (*)

  `*ptr` is the value at the address to which `ptr` currently points

  Printing `*ptr` gives the value of `myvar`

- References (rarely used):

  ```
  int& ref = myvar;
  ```

  `ref` is like an alias of `myvar` and cannot be re-assigned

Multiple Files, Header Files

- Using an additional cpp file:
  - Create additional header file:

    `Counter.cpp` and **`Counter.hpp`**
- Header file:
  - Contains declarations, is used to refer to the contents of the additional file
  - In **`Counter.cpp`** and wherever **`Counter.cpp`** is used (e.g. in **`Main.cpp`**):

    `#include "Counter.hpp"`
- Macros needed to avoid multiple declarations:

```
#ifndef Counter_hpp
#define Counter_hpp
   // Declarations go here
#endif /* Counter_hpp */
```

Counter Class in C++, Header File

```
#ifndef Counter_hpp
#define Counter_hpp

class Counter {
    int k;
public:
    Counter();
    void count();
    int getValue();
};

#endif /* Counter_hpp */
```

Note: Using one pair of files for a class is just a recommendation – not required by C++

Counter.hpp

Counter Class in C++, Body File

```
#include "Counter.hpp"

Counter::Counter() {
    k = 0;
}

void Counter::count() {
    k++;
}

int Counter::getValue() {
    return k;
}
```

Counter.cpp

Counter Class in C++, Main Program

```
#include <iostream>
#include "Counter.hpp"

int main(int argc, const char * argv[]) {

    // New counter instance (on stack)
    Counter ctr;
    std::cout << "Value of ctr: " << ctr.getValue()
       << std::endl;

    ctr.count();
    std::cout << "Value of ctr: " << ctr.getValue()
       << std::endl;

    return 0;
}
```

main.cpp

C++: Scope Resolution and Namespaces

- Scope operator (`::`) of C++:
  - Various purposes
- First main purpose:
  - Implementing member functions of classes outside the actual class
  - Example **`Counter::count()`**
  - In this case, only the function *prototype* is declared within the class
- Second main purpose:
  - Qualifying identifiers as belonging to a certain *namespace*
  - Example **`std::cout`** which belongs to the **`std`** namespace
- Declaring a new namespace:

  `namespace` ***`ns_name`*** **`{`** ***`declarations`*** **`};`**
- Using a given namespace for unqualified identifiers:

  `using namespace` ***`ns_name;`***

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Literature:

http://www.sfml-dev.org

M. G. Milchev: SFML Essentials, Packt Publishing 2015

SFML:
Simple and Fast Multimedia Library

- Relatively modern multimedia abstraction layer for C++
- Initiator and head of development: Laurent Gomila (France)
- Latest version: 2.3.2 (September 2015)

Audio module	Sounds, streaming (musics or custom sources), recording, spatialization
Graphics module	2D graphics module: sprites, text, shapes, ..
Network module	Socket-based communication, utilities and higher-level network protocols (HTTP, FTP)
System module	Base module of SFML, defining various utilities
Window module	Provides OpenGL-based windows, and abstractions for events and input handling

Slide Show with SFML (1)

```
#include <SFML/Graphics.hpp>
#include "ResourcePath.hpp"
#include <array>

//Global dimensions
const int SCREEN_WIDTH = 712;
const int SCREEN_HEIGHT = 712;
const int OFFSET_HOR = 100;
const int OFFSET_VER = 100;

//Directory name for pictures
const std::string gPicsDir = "pics";

//Picture file names
const int NUM_PICS = 4;
std::array<std::string, NUM_PICS> gPicFiles =
   {"frog.jpg","cows.jpg","elephant.jpg","tiger.jpg"};

const sf::Color bg = sf::Color(255, 228, 95, 255);  //background color
const sf::Time interval = sf::seconds(4.);
...
```

Slide Show with SFML (2)

```
...
int main(int, char const**) {
    // Create the main window
    sf::RenderWindow window
      (sf::VideoMode(SCREEN_WIDTH, SCREEN_HEIGHT), "SFML Slide Show");

    //Load pictures
    sf::Texture loadedPics[NUM_PICS];
    for(int i = 0; i < NUM_PICS; i++) {
        std::string picPath = resourcePath()
            +gPicsDir+"/"+gPicFiles[i];
        if (!loadedPics[i].loadFromFile(picPath)) {
            return EXIT_FAILURE;
        }
    }

    //Create a sprite to display
    sf::Sprite sprite;
    sprite.setScale(sf::Vector2f(2.f, 2.f));
    sprite.setPosition(sf::Vector2f(OFFSET_HOR, OFFSET_VER));

...
```

Slide Show with SFML (3)

```
...
    //Main loop
     int slideIndex = 0; //Index of picture to be shown
     bool updatePicture = true; //Do we need to change the picture?
     sf::Clock clock; //Create and start timer
     sf::Time timer;

     while (window.isOpen()) {
         //Display next picture if necessary
         if (updatePicture) {
             //Clear screen
             window.clear(bg);
             //Set picture and draw the sprite
             sprite.setTexture(loadedPics[slideIndex]);
             window.draw(sprite);
             //Update the window
             window.display();
             updatePicture = false;
             // Set timer
             timer = clock.getElapsedTime();
         }
...
```

Slide Show with SFML (4)

```
...
        // Process events
        sf::Event event;
        while (window.pollEvent(event)) {
            // Close window: exit
            if (event.type == sf::Event::Closed) {
                window.close();
            }
            // Arrow left pressed: previous picture
            if (event.type == sf::Event::KeyPressed
                    && event.key.code == sf::Keyboard::Left) {
                slideIndex = (slideIndex+NUM_PICS-1) % NUM_PICS;
                    //Strange C++ modulo
                updatePicture = true;
            }
            // Arrow right pressed: next picture
            if (event.type == sf::Event::KeyPressed
                    && event.key.code == sf::Keyboard::Right) {
                slideIndex = (slideIndex+1) % NUM_PICS;
                updatePicture = true;
            }
        }
...
```

Slide Show with SFML (5)

```
...
        // Check time interval
        if (clock.getElapsedTime() > timer+interval) {
            slideIndex = (slideIndex+1) % NUM_PICS;
            updatePicture = true;
        }
    }

    return EXIT_SUCCESS;
}
```